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(54) Method and apparatus for flushing residual paint from the internal flow passages in a paint distribution system.

(57) Residual paint is flushed from a paint distribution system (12) by simultaneously injecting a measured volume of atomized solvent and a quantity of compressed air into a manifold (58). Prior to injection, the solvent is first moved into a metering cylinder (44) having an outlet therefrom communicating with the manifold (58). A metering piston (46) is slideable within the metering cylinder (44) for urging the measured volume of solvent into the manifold (58). An air pressure responsive piston (32) is connected to the metering piston (46). At the appropriate times, air pressure is applied to the air piston (32) and also injected into the manifold (58). As the air piston (32) is moved, the connected metering piston (46) forces the measured solvent through an atomizer nozzle (56) and into the manifold (58).

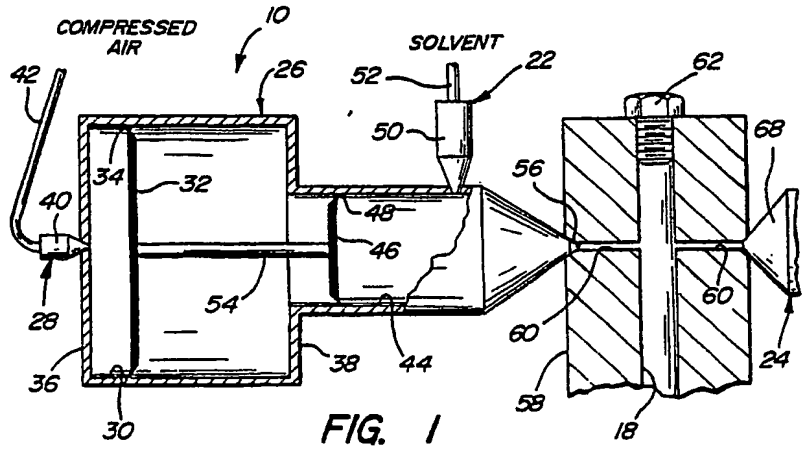

FIG. 1

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TECHNICAL FIELD

The subject invention relates generally to a method and apparatus for cleansing residual paint from the internal flow passages in an automated paint distribution system, and more particularly to the automated electrostatic spray coating art wherein a paint distribution system must be cleansed before a different color of paint is supplied to the sprayer.

BACKGROUND ART

In the automated sequential coating of workparts, e.g., vehicle bodies, each vehicle body is typically coated with a different color of paint than the preceding vehicle body. Therefore, a complete flushing of the paint distribution is required prior to application of the new paint color. The time required to change colors determines the through rate of workpieces, i.e., the conveyor speed and distance between workpieces conveyed past a paint spraying system.

Two factors of concern for businesses engaged in the automated spray coating art include the conservation of expensive materials and also the conservation of time. One such expensive material targeted for conservation is the liquid solvent used to flush residual paint from the distribution system. The prior art paint flushing techniques require large quantities of solvent to effectively clean the paint distribution system. Similarly, one such time requirement targeted for conservation is that required to fully clean the paint distribution system so that a new paint color can be introduced. The prior art teaches alternating injections of liquid solvent and high pressure air through the distribution system to flush the residual coating material from the flow passages. Although somewhat effective, this method requires a significant amount of time to pass the alternating liquid and air flows through the distribution system; thus, reducing the through rate of workparts to be painted different colors.

United States Patent Number 3,348,774 to Wiggins, issued October 24, 1967, is exemplary of the above-described method for flushing residual paint from a paint distribution system wherein a flow of compressed air is first moved through the internal flow passages in the distribution system, followed by a stream of solvent, which, in turn, is followed by another stream of compressed air. Likewise, the United States Patent Number 3,477,870 to Boretti et al, issued November 11, 1969, discloses a residual paint flushing method wherein liquid solvent is first moved through the internal flow passages of the distribution system, followed by a flow of high pressure air.

Through experimentation, it has been found that slightly improved results can be obtained by moving the liquid solvent in the compressed air simultaneously through the paint distribution system. United States Patent Number 3,155,539 to Juvinall, issued November 3, 1964, is exemplary of a prior art device wherein a mixture of compressed air and solvent are fed through the paint distribution system in order to flush residual paint. Also, the United States Patent Number 3,121,024 to Wampler et al, issued February 11, 1964, teaches the simultaneous movement of solvent and compressed air through the internal flow passages of a paint distribution system in order to flush residual paint.

Although the prior art flushing systems perform adequately and are capable of fully cleansing residual paint, they still require relatively large amounts of solvent and a relatively long period of time to fully cleanse the system. As technology continually progresses toward faster and more efficient painting of vehicle bodies, the time required to flush the paint distribution system along with the large quantities of solvent remain desired areas of advancements in this art.

SUMMARY OF THE INVENTION AND ADVANTAGES

A cleaning apparatus of the type for removing residual coating material from flow passages in a paint distribution system is provided. The apparatus comprises conduit means defining an internal flow passage for conveying coating material to a spraying device, a liquid supply means for supplying a liquid cleaning medium to the internal flow passage of the conduit means, and a gas supply means for supplying pressurized gas into the internal flow passage of the conduit means. The subject invention is characterized by including an injection means for simultaneously injecting an atomized spray of the liquid cleaning medium and the pressurized gas into the internal flow passage to remove residual coating material.

The subject invention also contemplates a method for removing residual coating material from flow passages in a paint distribution system comprising the steps of moving a liquid cleaning medium through a conduit, moving a pressurized gas through the conduit, and characterized by atomizing the liquid cleaning medium into a spray and mixing the spray with the pressurized gas in the conduit to remove residual coating material.

The subject invention achieves superior flush-

ing results by atomizing the liquid solvent and moving that atomized solvent with the compressed air through the internal flow passages in the conduit means of the paint distribution system. The improved efficiency provided by the high pressure atomized solvent flow translates into a substantial reduction in the amount of solvent required to effectively clean the paint distribution system, and also a substantial reduction in the amount of time required to complete the cleaning process. These advantages allow the spray coating system to coat a greater number of workparts at a given time than has heretofore been attainable.

BRIEF DESCRIPTION OF THE DRAWINGS

Other advantages of the present invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Figure 1 is a cross-sectional view of a solvent injection means according to the subject invention;

Figure 2 is a schematic of a paint distribution system according to the subject invention; and

Figure 3 is a simplified environmental view showing the cleaning apparatus of the subject invention disposed for operation in a spray painting booth.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the Figures, wherein like numerals indicate like or corresponding parts throughout the several views, a cleaning apparatus according to the subject invention is generally shown at 10. The cleaning apparatus 10 is particularly adapted for removing residual coating material, e.g., paint, from flow passages in a paint distribution system, generally indicated at 12. The paint distribution system 12, in turn, is particularly suited for use in the automated spray coating of workpieces, e.g., vehicle bodies, which are conveyed along a predetermined path. For illustrative purposes, a vehicle body is shown in phantom at 14 in Figure 3.

The subject apparatus 10 comprises a conduit means, generally indicated at 16, which defines at least one internal flow passage 18. The conduit means 16 conveys paint from a supply to a sprayer means, generally indicated at 20. The sprayer means 20 receives a flow of paint from the conduit means 16 for discharging the paint onto the vehicle body 14. A spray booth 21 is shown in Figure 3 and defines an isolated internal spray zone in which the conduit means 16 and the sprayer means 20 are disposed.

A liquid supply means is generally indicated at 22 in Figures 1-3 for supplying a liquid cleaning medium, i.e., a paint solvent, into the internal flow passage 18 of the conduit means 16. Similarly, a gas supply means is generally indicated at 24 in Figures 1-3 for supplying pressurized gas, preferably air, into the internal flow passage 18 of the conduit means 16. Therefore, the liquid supply means 22 provides the solvent, and the gas supply means 24 provides the air, which, together, are moved through the internal flow passage 18 of the conduit means 16 to flush residual paint from the paint distribution system 12 before a new color of paint is introduced.

The subject apparatus 10 is characterized by including an injection means, generally indicated at 26 in Figures 1-3, for simultaneously injecting an atomized spray of the liquid solvent and the pressurized air into the internal flow passage 18 to efficiently remove any residual paint. In this manner, the atomized solvent is rapidly moved through the internal flow passage 18 and functions to remove residual paint in much the same manner as in a sand blasting operation. In other words, the combination of the atomized solvent and compressed air moving through the internal flow passage 18 of the conduit means 16 functions as both an abrasive type cleaner wherein the physical effects of the rapidly moving solvent particles chip away at the residual paint, and also as a chemical cleaner wherein the solvent dissolves the residual paint and flushes it from the internal flow passage 18.

The injection means 26 includes a gas actuation means, generally indicated at 28 in Figure 1, which is associated with the liquid supply means 22 and supplied with pressurized gas from the gas supply means 24. The gas actuation means 28 forces the liquid cleaning medium into the internal flow passage 18 simultaneously with the pressurized gas injection from the gas supply means 24. More specifically, the gas actuation means 28 includes an air cylinder 30 in communication with the gas supply means 24. An air pressure responsive piston 32 is slideably disposed in the air cylinder 30 and is responsive to the pressurized gas from the gas supply means 24. As best shown in Figure 1, the air piston 32 is a plate-like member having a resilient peripheral lip 34 biased radially outwardly to engage the inner cylindrical wall of the air cylinder 30. The air cylinder 30 extends axially between an end wall 36 and a connecting wall 38. The air piston 32, therefore, is axially moveable within the air cylinder 30 between the end wall 36

and the connecting wall 38, and resembles a conventional positive displacement piston/cylinder assembly.

A gas supply valve 40 is disposed between the gas supply means 24 and the air cylinder 30 for selectively communicating pressurized gas to the interior of the air cylinder 30. The gas supply valve 40 is fixedly attached to and extends through the center of the end wall 36. A pressurized gas flow tube 42 extends from the gas supply valve 40 and communicates with the gas supply means 24. As will be described in detail subsequently, the gas supply valve 40 is pneumatically actuated from a control 43 outside the spray booth 21 for allowing compressed air to enter the air cylinder 30 at predetermined times in the coating cycle of the paint distribution system 12.

The gas actuation means 28 further includes a metering cylinder 44 which is in communication with the liquid supply means 22 for measuring a predetermined volume of solvent to be injected into the internal flow passage 18. A metering piston 46 is slideably disposed in the metering cylinder 44 in much the same manner as the air piston 32. The metering piston 46 includes a peripheral annular lip 48 biased radially outwardly toward the inner wall of the metering cylinder 44. The metering cylinder 44 is integral with the air cylinder 30 and extends axially from the connecting wall 38 of the air cylinder 30. The metering piston 46 is moveable within the metering cylinder 44 between the connecting wall 38 and a forward end of the metering cylinder 44.

A liquid supply valve 50 is disposed between the liquid supply means 22 and the metering cylinder 44 for injecting liquid solvent into the metering cylinder 44. More particularly, as best shown in Figure 1, the liquid supply valve 50 extends radially outwardly from the cylindrical wall of the metering cylinder 44 and includes a liquid flow tube 52 for communicating the liquid solvent from the liquid supply means 22 to the liquid supply valve 50. As will be described in detail subsequently, the liquid supply valve 50 is pneumatically actuated at predetermined times from the control disposed outside the spray booth 21.

A connection means 54 extends between the air piston 32 and the metering piston 46 for moving one of the pistons in response to the movement of the other. More particularly, as best shown in Figure 1, the connection means 54 comprises a rigid rod 54 extending straight and axially between the air piston 32 and the metering piston 46 and fixedly connected at each end to the respective pistons 32, 46 for allowing movement in unison of the pistons 32, 46.

The air cylinder 30 has a first predetermined cross-sectional area taken perpendicular to the longitudinal axis thereof. Likewise, the metering cylinder 44 has a second predetermined cross-sectional area taken perpendicular to the coincidental longitudinal axis of the air 30 and metering 44 cylinders. As shown in the Figures, the first cross-sectional area is larger than the second cross-sectional area for multiplying the pressure in the metering cylinder 44 relative to air pressure applied to the air cylinder 30. More particularly, the difference in cross-sectional areas of the air 30 and metering 44 cylinders results in a proportional multiplication of the velocity of the solvent injected from the metering cylinder 44 relative to the velocity of compressed air moving into the air cylinder 30 through the gas supply valve 40. As best shown in Figure 1, the injection means 26 includes an atomizer nozzle 56 disposed between the second cylinder 44 and the conduit means 12. The accelerated velocity of solvent exiting the metering cylinder 44 is moved through the atomizer nozzle 56 and into the conduit 12 in an atomized state.

As best shown in Figures 2 and 3, the conduit means 16 includes an upstream manifold 58 having a plurality of closable fluid inlets 60 to the internal flow passage 18. The manifold 58 is associated with a plurality of fluid mediums to be injected into the internal flow passage 18, such as the above-mentioned solvent and compressed air, as well as numerous paint colors. The manifold 58 is preferably an elongated member having a longitudinally extending passage therethrough defining the internal flow passage 18. A threaded stopper 62 is disposed in one end of the manifold 58, and the conduit means 16 extends from the other end of the manifold 58. Pneumatically actuated valves 64 are associated with each of the inlets 60 to the manifold 58 to selectively allow the injection of a particular paint medium into the internal flow passage 18. Although six inlets 60 are provided in addition to the two inlets 60 for the solvent and compressed air, it will be appreciated that any number of additional inlets, either more or less, can be provided with the subject apparatus.

The conduit means 16 also includes a flow regulator means 66 disposed downstream of the manifold 58 for controlling the volumetric flow rate of paint through the conduit means 16 and to the spraying means 20. As is well known in the art, the subject flow regulator means 66 is pneumatically operated to actuate a liquid and air impermeable diaphragm supported inside of the housing of the flow regulator means 66. The diaphragm actuates a needle toward and away from a ball valve disposed in a seat to allow more flow through the conduit means 16 by moving the ball away from its seat, and less flow through the conduit means 16 by moving the ball toward its seat.

As best illustrated in Figure 2, the gas supply

means 24 includes a pneumatic main valve 68 responsive to a pneumatic signal for selectively controlling the injection of pressurized gas into the manifold 58. The pneumatic main valve 68 is associated with one of the manifold inlets 60 for communicating with the internal flow passage 18.

With reference to the structure of the subject apparatus 10 as described above, the operation of the preferred embodiment will be addressed presently. Initially, the paint distribution system 12 awaits a command to initiate the spray coating of a vehicle body 14. The internal flow passage 18 of the conduit means 16 is fully cleansed and ready for the introduction of a predetermined color of paint. Upon the appropriate command from an operator or computer control system 43 disposed outside the spray booth 21, one of the paint valves 64 is commanded to open to allow the associated color of paint into the manifold 58 while the remaining paint valves 64, the pneumatic main valve 68 and the injection means 26 remain closed. The paint thus fed into the manifold 58 is moved under pressure through the internal flow passage 18 and into the flow regulator means 66. Traveling through the flow regulator means 66, the liquid paint reaches the sprayer means 20 where it is atomized and electrostatically charged by electrodes disposed in an annular ring 70, as shown in Figure 3. The electrostatically charged paint particles are attracted to the grounded vehicle body 14, and uniformly deposit themselves thereon.

As the paint is moved through the paint distribution system, the gas supply valve 40 of the injection means 26 is closed while the liquid supply valve 50 is open to allow liquid solvent to enter the metering cylinder 44. The pneumatic valve associated with the metering cylinder 44 remains closed to prevent the liquid solvent from entering the manifold inlet 60 associated therewith. As the liquid solvent fills the metering cylinder 44, the fluid pressure urges the metering piston 46 rearwardly in the metering cylinder 44, toward the connecting wall 38. Although not shown, it will be appreciated that appropriate venting must be provided in the air cylinder 30 so that resistance due to trapped air from the air piston 32 will be eliminated. When the metering cylinder 44 has been completely filled, the predetermined quantity of solvent has been measured. The liquid supply valve 50 is closed and remains closed throughout the entire flushing operation.

When the movement of paint through the conduit means 16 has ended, by closing the associated paint valve 64, the flushing cycle is ready to begin. Referring to Figure 2, it will be appreciated by those skilled in the art that the necessary waste, or recovery, lines extending from the spraying means 20 must be provided, even though not shown in the Figures.

Generally, the pneumatic main valve 68 of the gas supply means 64 will be first opened in order to force out all of the paint trapped in the conduit means 16 between the manifold 58 and the spraying means 20. This paint will typically be collected for reuse. After this operation is complete, the residual coating material which has adhered to the internal flow passage 18 must be removed. With this, the gas supply valve 40 of the injection means 26 and the pneumatic main valve 68 are simultaneously opened, along with the pneumatic valve disposed between the metering cylinder 44 and the inlet 60, so that compressed air is allowed to enter the air cylinder 30 of the injection means 26. This compressed air acts against the air piston 32 to move the air piston 32 axially in the air cylinder 30 toward the connecting wall 38. Accordingly, movement of the air piston 32 also moves the metering piston 46 via the connecting rod 54 to urge the liquid solvent in the metering cylinder 44 into the manifold 58.

The solvent expelled from the metering cylinder 44 is first atomized by forcing it through the atomizer nozzle 56. The atomized spray of solvent is then mixed with the pressurized air in the conduit 16. In a particle sense, the atomized solvent and the pressurized air are simultaneously injected into the conduit means 16 to efficiently remove the residual paint by both abrasive and chemical cleaning actions. When the pistons 32, 46 have completed their stroke, thus injecting the entire premeasured volume of liquid solvent contained in the metering cylinder 44, the pneumatic valve associated with the metering cylinder 44 is closed and the conduit means 16 is prepared for the injection of a new color of paint via another of the paint valves 64.

As the next color of paint is moved through the conduit means 16, the liquid supply valve 50 is reopened to allow a new quantity of solvent to enter the metering cylinder 44, thus, moving the metering piston 46 axially in the metering cylinder 44. It will appreciated, that the axial placement of the liquid supply valve 50 relative to the metering cylinder 44 must be such that when the metering piston 42 has completed its stroke during the injection of solvent into the manifold 58, the liquid supply valve 50 remains in a position to inject the solvent on the liquid-contacting face of the metering piston 46.

The injection of atomized solvent into the internal flow passage 18 of the paint distribution system 12 is highly advantageous in that a smaller quantity of liquid solvent is required to remove the residual coating material, and the time required for the flushing process is thereby substantially reduced. Additionally, by injecting the liquid solvent into the

conduit means 16 at a greater pressure than the pressure of the compressed air in the gas supply means 24, there is never the threat that the high pressure compressed air will cause a back-up in the liquid solvent supply line 52.

The invention has been described in an illustrative manner, and it is to be understood that the terminology which has been used is intended to be in the nature of words of description rather than of limitation.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims wherein reference numerals are merely for convenience and are not to be in any way limiting, the invention may be practiced otherwise than as specifically described.

Claims

1. A cleaning apparatus (10) of the type for removing residual coating material from flow passages in a paint distribution system (12), said apparatus (10) comprising: conduit means (16) defining an internal flow passage (18) for conveying coating material to a spraying device (20); liquid supply means (22) for supplying a liquid cleaning medium into said internal flow passage (18) of said conduit means (16); gas supply means (24) for supplying pressurized gas into said internal flow passage (18) of said conduit means (16); and characterized by including injection means (26) for simultaneously injecting an atomized spray of the liquid cleaning medium and the pressurized gas into said internal flow passage (18) to remove residual coating materia.

2. A cleaning apparatus (10) of the type for removing residual coating material from flow passages in a paint distribution system (12), said apparatus (10) comprising: conduit means (16) defining an internal flow passage (18) for conveying coating material; sprayer means (20) communicating with said conduit means (16) for discharging coating material onto a workpart (14); liquid supply means (22) for supplying a liquid cleaning medium into said internal flow passage (18) of said conduit means (16); gas supply means (24) for supplying pressurized gas into said internal flow passage (18) of said conduit means (16); and characterized by including injection means (26) for simultaneously injecting an atomized spray of the liquid cleaning medium and the pressurized gas into said internal flow passage (18) to remove residual coating material.

3. A cleaning apparatus (10) of the type for removing residual coating material from flow passages in a paint distribution system (12), said apparatus (10) comprising: a spray booth (21) defining an isolated internal spray zone; conduit means (16) disposed in said spray booth (21) and defining an internal flow passage (18) for conveying coating material; sprayer means (20) disposed in said spray booth (21) and communicating with said conduit means (16) for discharging a liquid cleaning medium onto a workpart (14); liquid supply means (22) for supplying a coating material into said internal flow passage (18) of said conduit means (16); gas supply means (24) for supplying pressurized gas into said internal flow passage (18) of said conduit means (16); and characterized by including injection means (26) disposed in said spray booth (21) for simultaneously injecting an atomized spray of the liquid cleaning medium and the pressurized gas into said internal flow passage (18) to remove residual coating material.

4. An apparatus (10) as set forth in any one of claims 1, 2 or 3 further characterized by said injection means (26) including gas actuation means (28) associated with said liquid supply means (22) an supplied from the pressurized gas for forcing the liquid cleaning medium into said internal flow passage (18) simultaneously with the pressurized gas injection.

5. An apparatus (10) as set forth in claim 4 further characterized by said gas actuation means (24) including an air cylinder (30) in communication with said gas supply means (24) and an air pressure responsive piston (32) slideably disposed in said air cylinder (30).

6. An apparatus (10) as set forth in claim 5 further characterized by said gas actuation means (24) including a metering cylinder (44) in communication with said liquid supply means (22) and a metering piston (46) slideably disposed in said metering cylinder (44).

7. An apparatus (10) as set forth in claim 6 further characterized by including connection means (54) extending between said air (32) and said metering (46) pistons for moving one of said pistons in response to movement of the other.

8. An apparatus (10) as set forth in claim 7 whereby said air cylinder (30) includes a first predetermined cross-sectional area, and said metering cylinder (44) includes a second predetermined cross-sectional area, further characterized by said first cross-sectional area being larger than said second cross-sectional area.

9. An apparatus (10) as set forth in claim 8 further characterized by including a gas supply valve (40) disposed between said gas supply means (24) and said air cylinder (30).

10. An apparatus (10) as set forth in claim 9 further characterized by including a liquid supply valve (50) disposed between said liquid supply

means (22) and said metering cylinder (44).

11. An apparatus (10) as set forth in claim 10 further characterized by said injection means (26) including an atomizer nozzle (56) disposed between said metering cylinder (44) and said conduit means (16).

12. An apparatus (10) as set forth in claim 11 further characterized by said conduit means (16) including a manifold (58) having a plurality of closeable inlets (60).

13. An apparatus (10) as set forth in claim 12 further characterized by said conduit means (16) including flow regulator means (66) disposed downstream of said manifold (58) for controlling the volumetric flow rate of liquid coating material through said conduit means (16).

14. An apparatus (10) as set forth in claim 13 further characterized by said gas supply means (24) including a pneumatic main valve (68) responsive to a pneumatic signal for selectively controlling the injection of pressurized gas into said manifold (58).

15. An apparatus (10) as set forth in claim 14 further characterized by said air cylinder (30) and said metering cylinder (44) being integral, with said metering cylinder (44) extending axially from said air cylinder (30).

16. A cleaning apparatus (10) of the type for removing residual coating material from flow passages in a paint distribution system (12), said apparatus (10) comprising: a conduit (16); a gas supply (24) communicating with said conduit (16); an air cylinder (30) communicating with said gas supply (24) and having a first predetermined cross-sectional air; an air pressure responsive piston (32) slideably disposed in said air cylinder (30); a metering cylinder (44) extending axially from said air cylinder (30) and having a second predetermined cross-sectional area smaller than said first cross-sectional area; a metering piston (46) slideably disposed in said metering cylinder (44); a rigid rod (54) extending straight and axially from said air piston (32) to said metering piston (46); an atomizer nozzle (56) disposed between said metering cylinder (44) and said conduit (16); a liquid cleaning medium supply (22) communicating with said metering cylinder (44); a liquid supply valve (50) disposed between said liquid supply (22) and said metering cylinder (44); a gas supply valve (40) disposed between said gas supply (24) and said air cylinder (30); and a pneumatic main valve (68) disposed between said gas supply (24) and said conduit (16).

17. A method for removing residual coating material from flow passages in a paint distribution system (12), said method comprising the steps of: moving a liquid cleaning medium through a conduit (16); moving a pressurized gas through the conduit (16); and characterized by atomizing the liquid cleaning medium into a spray and mixing the spray with the pressurized gas in the conduit (16) to remove residual coating material.

18. A method as set forth in claim 17 further characterized by applying energy from he pressurized gas to inject the liquid cleaning medium into the conduit (16).

19. A method as set forth in claim 18 further characterized by injecting the liquid cleaning medium into the conduit (16) at a pressure greater than that exerted by the pressurized gas.

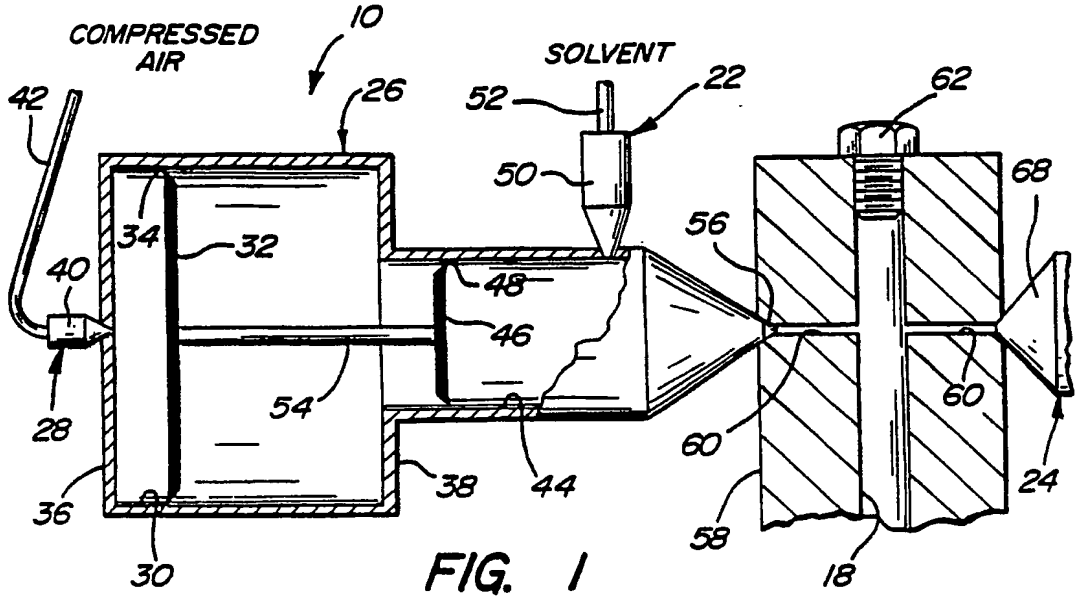
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FIG. 1

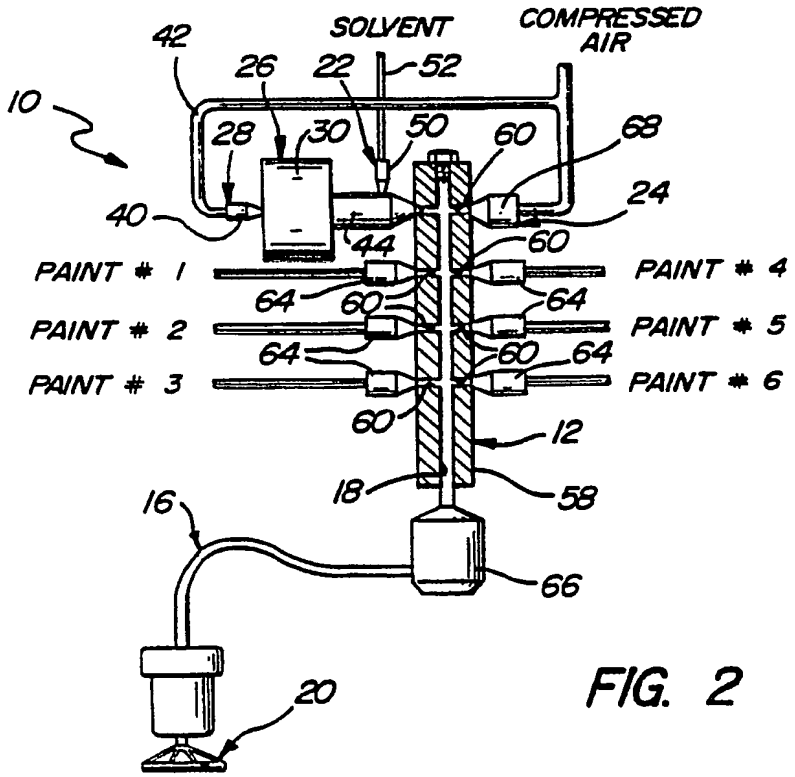
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FIG. 2

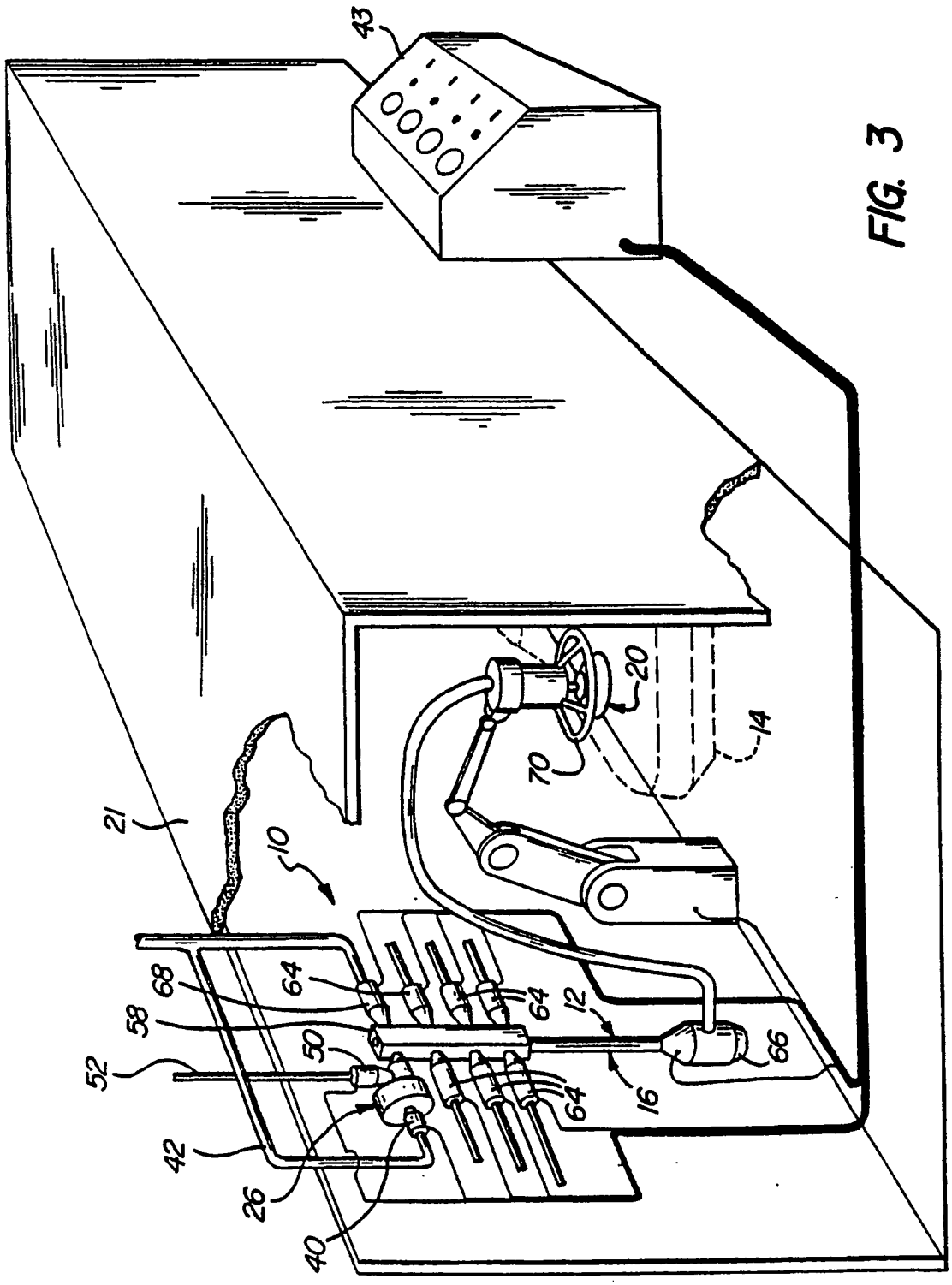

FIG. 3